

# I H O G



## **Interagency Helicopter Operations Guide**

**NFES 1885**

**January  
2002**

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The agencies would like to acknowledge the assistance of the many product manufactures, as well as the National Fire Protection Association, the International Fire Service Training Association, and the United States Department of the Army, who kindly furnished material used in the production of this document.

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The IHOG and IHOG Supplement Forms Package will be available for viewing and downloading at: <http://www.nifc.gov/ihog>.

Additional copies of the IHOG may be ordered from: National Interagency Fire Center, ATTN: Great Basin Cache Supply Office, 3833 S. Development Avenue, Boise, Idaho 83705. Order NFES # 1885. The IHOG Supplement Forms Package is available separately by ordering NFES # 1878.



## AMC

### INTERAGENCY AVIATION MANAGEMENT COUNCIL

To: Users of the *Interagency Helicopter Operations Guide*

From: Interagency Aviation Management Council

Date: January 24, 2002

Subject: Publication of 2002 *Interagency Helicopter Operations Guide* (IHOG)

The IHOG has been revised for new publication in 2002. Changes include revisions proposed by the IHOG Working Group, coordinated by the Aviation Management Council (AMC) and approved by the U.S. Forest Service and the Department of the Interior in May 2001. It also includes interim helicopter operations policy coordinated by the AMC and approved by the USFS and DOI in July/August 2001. Finally, other IHOG revisions were necessary to be compatible with changes to the national Type I and II CWN helicopter contract drafted in the fall of 2001, and these changes were also approved by the USFS and DOI.

We are confident that the 2002 version of the IHOG provides the necessary changes identified by field personnel and agency program managers. The IHOG is a dynamic document; and work will begin immediately to prepare for the next revision.

Publication as a cache item and placement on the NIFC Website is authorized. Copies of this memo and a list of all revisions will be included at the front of the 2002 IHOG.

Michael Martin  
Acting Director  
Office of Aircraft Services  
Department of the Interior

Tony Kern  
Assistant Director  
Aviation & Fire Management  
U.S. Forest Service

## **IHOG Revision Summary**

### **January 17, 2002**

#### **BACKGROUND**

The IHOG Working Group met in April, 2000 and again in January, 2001 to consolidate and review proposed revisions of the IHOG that were generated from all agencies at all levels. The process allowed virtually eight months of comment period with several calls through agency ranks for revision proposals. Each proposal was discussed and analyzed and either rejected or approved. The IHOG Working Group was represented as follows:

Bob Quirino, (Chair, USFS)  
Jim Ramage, (States, CDF)  
Cameron Dingman, BLM

Dave Underwood, BIA  
Guy Keene, NPS  
Mark Reese, OAS

IHOP Steering Committee members reviewed and approved the proposed revisions on February 13, March 9, April 3 and November 8, 2001:

Kevin Hamilton, (Chair, BLM)  
Kris Damsgaard, (OAS)  
Sheldon Mack, (STATES)  
Stan Anderson, (BIA)  
JP Johnston, (USFS)

Jon Rollens, (USFS)  
Gary Johnson, (NPS)  
Al Rice, (OAS)  
Bill Butler, (USFWS)

In August, 2001 the Aviation Management council issued interim IHOG revisions in Chapter 2 and the bucket policy in Chapter 7. This interim policy will be incorporated into the IHOG.

On December 5, 2001 Jon Rollens, Dave Underwood and Kevin Hamilton met to finalize additional revisions. These revisions were necessary due to recent changes to the National CWN Type I & II Helicopter Contract and recent agreements to make changes to the PMS 310-1 and Ch. 2 of the IHOG concerning Helicopter Manager position standards.

***The following revision summary is provided. These revisions are already incorporated in the 2002 IHOG and identified by the symbol: ✎***

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## **Table of Contents**

The entire Table of Contents will be updated to reflect any new sections or necessary page number changes, etc.

## **Chapter 1**

Section II, following the first paragraph: **Add** the following Important Note:

**IMPORTANT NOTE:** The contractual relationship between the vendor and government is key to successful helicopter operations. There may be discrepancies between direction found in this guide and applicable helicopter contract language. When discrepancies arise, the current helicopter procurement document language should be followed. However, if discrepancies cannot be resolved to the satisfaction of the vendor and government representative, the Contracting Officer should be consulted.

## **Chapter 2**

Sections I & II: **Replace** sections I & II entirely with the following:

- I     **Introduction.** This chapter establishes common duties and responsibilities for individuals functioning in helicopter or helibase management positions. Position descriptions cover both incident and project operations. Minimum daily staffing requirements for fire helicopters are also established.
  
- II.   **Qualifications, Certification, Currency and Experience.** To meet minimum qualification standards, an individual must be trained, experienced, current and certified. Many types of helicopter and helibase management positions exist, for incident and project applications. Training, experience and currency requirements for various positions are found in a variety of documents.
  - A     **Incident (Fire and All-Risk) Helicopter and Helibase Management Positions.** Minimum qualification standards for individuals serving in helicopter and helibase management positions on wildland and prescribed fire are established in the PMS 310-1, Wildland and Prescribed Fire Qualification System Guide (NWCG). Each agency may require additional training, experience and currency standards of their employees, as long as they meet the 310-1 minimum standards. Certification in these positions utilizes the Incident Qualifications System (Red-card) and is normally authorized by the local unit Fire Management Officer.
  
  - B     **Non-Incident (Project) Helicopter and Helibase Management Positions.** Qualification and training standards for Project (non-fire) Helicopter and Helibase

Management Standards are displayed in Charts 2-1, 2-2, 2-3 of this chapter. The local unit Aviation Manager has primary responsibility for certification in these positions. State or Regional aviation staff shall provide oversight, guidance and review for certification.

- C Specialized Helicopter Positions.** Minimum position qualification standards for many specialized helicopter positions are established in various interagency guides and handbooks. Examples of these include the Interagency Aerial Ignition Guide, Interagency Helicopter Rappel Guide, Shorthaul Handbook, Aerial Capture Eradication and Tagging of Animals (ACETA) Handbook, etc. State or Regional aviation staff shall provide oversight, guidance and certification.

**Remove** Charts 2-1, 2-2, 2-5, 2-6

**Re-number** Chart 2-3A as: Chart 2-1

**Re-number** Chart 2-3B as: Chart 2-2

**Re-number/Rename** Chart 2-4 as: Chart 2-3 and “Project Helibase Position Training, Qualifications and Experience Requirements”.

**Revise** the new Chart 2-3 as follows:

Chart 2-3 Project Helibase Position Training, Qualifications and Experience Requirements

POSITION	PREREQUISITES	TRAINING REQUIREMENTS	CURRENCY
NOTE: For all positions below, prerequisites include successful training assignments on incidents or projects and completion of the Job Task Book for the position.			Experience in the position, either on project or incident, every 3 years.
Helibase Manager Type I	Helibase Manager Type II		
Helibase Manager Type II	Helispot Manager and Helicopter Manager	S-371, S-372	
Deck Coordinator	Helicopter Crewmember, Parking Tender, Loadmaster, TOLC,	S-271	
Takeoff and Landing Coordinator	Helicopter Crewmember ABRO	S-271	
Aircraft Base Radio Operator (ABRO)	Helicopter Crewmember	S-271	

Helispot Manager*	Helicopter Crewmember Loadmaster, Parking Tender	S-271	
Loadmaster*	Helicopter Crewmember	S-271	
Aircraft Timekeeper*	Helicopter Crewmember	S-271	
Parking Tender*	Helicopter Crewmember	S-271	

\* At the time of IHOG publication, no Job Task Books have been developed for these positions.

**Change** Chart number from 2-7 to 2-4. **Replace** the entire new Chart 2-4 with the following:

Chart 2-4: Minimum Daily Staffing Requirements for Fire Helicopters

Type Helicopter	FAA Standard/Transport Category	FAA Standard Category Temporarily Designated for Limited Use*	FAA Standard Category Permanently Designated for Limited Use* <u>or</u> FAA Restricted Category
1	Manager plus Four (4) Helicopter Crewmembers	Manager only	Manager only
2	Manager plus Three (3) Helicopter Crewmembers	Manager only	Manager only
3	Manager plus Two (2) Helicopter Crewmembers		
CWN Helicopter and Module must mate up away from Incident(s) or Fire Operations.			

**Add** the following paragraph and Important Note immediately following Chart 2-4:

\*Limited Use Designation: This is an agency term used to denote a helicopter that can only be utilized in a limited role (not for passenger transport). Use would typically include external cargo transport or water/retardant dropping missions. This may be a temporary designation as described above. Or it may be a permanent designation dictated by the contract or agency policy. During the period that a helicopter is designated as “limited use”, the assigned Helicopter Manager/Module Members are the only government employees authorized to function as aircrew and only when necessary (examples: ferry flight, initial attack size-up and bucket deployment or other non-external load missions).

**IMPORTANT NOTE:** The appropriate agency Aviation Manager at the State or Regional level must grant approval any time a Standard Category helicopter is temporarily designated for Limited Use missions or re-designated to perform standard (personnel transport) missions. Any helicopter performing standard use missions requires full staffing of Helicopter Manager and Module

Section III: In the first paragraph, last sentence, **Delete:** “..., which is a manager plus four crewmembers”

Section III: In the second paragraph, at the end of first sentence: **Add:** “for personnel and aircraft.”

Section III: After the second paragraph, **Add** the following Important Note:

**IMPORTANT NOTE:** Two (2) Type I or Type II designated as “limited use” or FAA Restricted Category helicopters may be managed by one qualified CWN Fire Helicopter Manager only when the following conditions are met:

- 1) An order for another CWN Fire Helicopter Manager for the second helicopter has been placed and is actively trying to be filled.
- 2) Both helicopters are working out of the same helibase and are physically located side-by-side.
- 3) A Helibase Manager is assigned.
- 4) Aerial supervision is being provided.
- 5) The appropriate agency Aviation Manager at the State or Regional level must grant approval on a case-by-case basis.

**The management of two helicopters by one HEMG, as described above, should not be a standard operating procedure.**

Section III, A.: In the second paragraph: **Replace:** “Project Flight Manager” with “Helicopter Flight Manager”.

Section V, C, 4. In the blocked note at bottom of page: **Add** “...requirements.” to the last sentence.

### **Chapter 3**

Section V, Footnote #3 at bottom of page, last sentence: **Replace:** “USDA-FS Hourly



Comparison Index” *with* “Interagency Helicopter Approval Performance Index (IHAPI)”

Section E, 1, second paragraph: **Replace:** “Hourly Comparison Index” *with* “Interagency Helicopter Approval Performance Index (IHAPI)”

Section F, 1, fourth paragraph: **Replace:** “Hourly Comparison Index” *with* “Interagency Helicopter Approval Performance Index (IHAPI)”. **Delete:** “....developed by the USDA-FS...”

Section J, 1, paragraph titled Local Unit Hazard Maps: **Delete:** the last sentence of the paragraph entirely.

Section J, 1, C, in the second bulleted paragraph: **Delete** the word “temporary”.

## **Chapter 4**

Section II, E, 1: **Add:** “...(maximum)...” after the word “intervals”

## **Chapter 5**

Section VI, first paragraph, second sentence: **Change** the entire sentence to read: “The inspection sticker should be located on or in the vehicle in a conspicuous location”.

## **Chapter 7**

Section II, A, following the third bulleted sentence: **Add** the following Important Note:

**IMPORTANT NOTE:** The government representative MAY participate in the completion of load calculations. However, the pilot is ultimately responsible for content accuracy.

Section III, B.2, third bullet, **Replace** paragraph with:

“ ± change in Operating Weight such as changes to the helicopter Equipped Weight, changes in flight crew weight or an increase of more than five gallons in fuel load. (A decrease in fuel load at the same temperature and elevation will, of course, increase allowable payload; a new calculation may be completed to reflect increased capability.)”

Section III, B, following the text for part 13: **Add** the following text and notes:

14. **Managing Helicopter Bucket Payloads.** Helicopter bucket operations require attention to ensure that allowable payloads are not exceeded. Allowable bucket payloads must be calculated for current fuel loads and local environmental conditions. Actual bucket payloads can only be accurately determined if the bucket is filled to adjusted capacity or an on-board load meter is used.

The following procedures **shall** be used for all bucket operations:

- Determine allowable payload using the Interagency Load Calculation method, appropriate HOGE helicopter performance charts and current local temperature and pressure altitude. Performance enhancement charts (also known as “wind charts”) that attempt to take advantage of prevailing winds **are not** authorized. Since buckets are external jettisonable loads, the weight reduction may be omitted from the load calculation process with pilot approval.

The following procedures **shall** be used for all bucket operations except helicopters equipped with electronic helicopter hook load measuring systems (load cells) that provide a cockpit readout of the actual external load and a bucket that is equipped with a gating system that allows part of the load to be dispensed while retaining the remainder of the load:

- At the beginning of the fuel cycle, adjust the bucket capacity so that the actual payload, when the bucket is filled to the adjusted capacity, does not exceed the allowable payload.. Use **8.3 pounds per gallon of water**. If mixed fire retardants are being delivered by bucket use the appropriate weight per gallon for that mixture. The weight of the empty bucket and any associated suspension hardware (lines, cables, connectors, etc.) must also be included in calculating the actual payload. The calculation of the actual bucket payload must be documented on the load calculation form or separate load manifest.

**SAFETY ALERT: IF THE HELICOPTER BUCKET PROVIDED BY THE CONTRACTOR CANNOT BE ADJUSTED TO THE ALLOWABLE PAYLOAD FOR CURRENT, LOCAL ENVIRONMENTAL CONDITIONS, BUCKET OPERATIONS MUST NOT BE CONDUCTED.** If this situation occurs, consult with the appropriate Contracting Officer to determine contractual ramifications and necessary actions.

**CAUTION:** There are many different manufacturers and designs of helicopter buckets. Capacity adjustments are made in various ways: removing plugs, opening zippers or cinching collapsible/foldable buckets (see Ch 9. Section VII, paragraph K). Capacity at each position or adjustment level should be marked on the bucket. Collapsible buckets with cinch straps should only be adjusted to the marked graduations (as an example 90%, 80%, 70%, 60%). Attempts to establish intermediate graduations or capacities below the manufacturer's minimum graduation (tying knots, etc.) is prohibited as this results in estimated capacities and may interfere with the release mechanism.

- After the bucket has been adjusted so that the actual payload will be within the allowable payload, bucket operations may begin. The pilot will be directed to fill the bucket to the adjusted capacity each time (**no partial dips for performance planning purposes**). Thus, the same payload will be carried on each trip. As fuel is burned, the allowable payload will increase but the actual payload will remain constant. If so desired, after a period of time (for example, 30 minutes), the bucket may be readjusted to the new allowable created by fuel burn-off.

## **Chapter 8**

Section III, A, following the second paragraph: **Add** the following Important Note:

If an unimproved landing area will be used on a recurring but limited basis, improvements will be made. The appropriate authority (agency determined) will identify the level of improvement and approve the extended use. Recommendation: 1) Resource users should prepare a Project Aviation Safety Plan. 2) For large fire operations, extended use will be approved by the Air Operations Branch Director. 3) For Initial Attack operations, the Helicopter Manager must make this determination.

Use of unimproved landing sites on a recurring basis is discouraged. When logistical and environmental concerns allow, the site should be brought up to IHOG Helispot standards.

## **Chapter 9**

Section III, Paragraph 1, first sentence: **Add** the following text to the end of the first sentence: "...clothing and equipment that provide protection to an individual in a hazardous environment."

Section III, Paragraph 1: **Delete** last sentence.

Section III: **Add** new paragraph after Paragraph 2: "Chart 9-2 establishes PPE requirements for ground operations when helicopters are operating. It is at the discretion of the Helibase Manager,

Deck Coordinator or Helicopter Manager to establish the appropriate level of PPE on the ground when no active helicopter operations are being conducted. Consult the specific helicopter procurement document for vendor personnel PPE requirements.”

Section III, Chart 9-1: **Add** an “x” to the POINT-TO-POINT line under columns #'s 1, 4, 6, 8.

Section III, A, first paragraph, first sentence: **Replace** “...an aviation-approved flight helmet or hard hat...” *with* “...only approved headgear...”

Section III, A, 1. **Replace** first paragraph with the following two paragraphs:

**Aviator Flight Helmets.** The aviator flight helmet, consisting of a one-piece hard shell made of polycarbonate, Kevlar, carbon fiber or fiberglass must cover the top, sides (including the temple area and to below the ears) and the rear of the head. The helmet shall be equipped with a chinstrap and shall be appropriately adjusted for proper fit; helmets should be individually fitted for maximum protection.

Flight helmets for helicopter usage must conform to a national certifying agency standard such as DOT, Snell, SFI or an appropriate military standard, or appropriate equivalent standard. Examples of flight helmets currently approved include the SPH-3, SPH-4, SPH-5, HGU-56 & HGU-84. “Shorty” helmets are not approved. Helmets designed for use in fixed wing aircraft do not provide adequate protection for helicopter occupants and are not approved for helicopter use.

Section III, F, in the paragraph which follow the bulleted items: **Replace:** the word “exemptions” *with* “waivers”.

Section VI, A, first paragraph, second sentence: **Delete:** “...and helispots.” **Add** (for Helispot requirements, see Chart 8-2)

Section VI, Chart 9-7, in the chart heading: **Delete:** “...And Helispots”

Section VII, C, First paragraph: **Add** after second sentence “ Or maybe loaded and locked in a single motion with one hand.”

Section VII, C, First Paragraph, Last sentence: **Change** to read: “The release must be both manually and electrically operated by the pilot from the cockpit. “

Section VII, F, 3: **Add** the following Important Note following the existing paragraph:

**IMPORTANT NOTE:** Synthetic longline may be utilized by the vendor as suspension cable sections when specified in the procurement document and approved by the agency aircraft inspector.

Section VII, K: **Add** the following Important Note: “Refer to Chapter 7, III, 14, for more information on managing bucket payloads.”

Section XIII, Chart 9-12, **Change**: the quantity values upwards to match items (typo).

## **Chapter 10**

Section V, E: **Replace** the 2<sup>nd</sup> bulleted sentence *with* “Personal items carried on board must be adequately secured.”

Section V, F: **Replace** the 3<sup>rd</sup> bulleted item *with* “Secure all items, especially when flying with the door(s) off.”

Section V, G: **Change** the 4<sup>th</sup> bulleted item to read “Maintain tight control of all personal items.”

Exhibit 10-2, Aircraft Safety Briefing (Front): **Add**: briefing item #8: “Identify any Hazardous Materials that will be transported and notify the Pilot. Take appropriate actions.”

## **Chapter 11**

Section XI, A: **Delete** bulleted sentence #2.

Section XI, A: **Change** the CAUTION to read: “All packs must be secured if carried in the passenger compartment. Packs shall not be carried unsecured in a passenger’s lap or on the floor. Packs can be stored separately in the cargo compartment, in external cargo racks or transported in an external sling. ”

Section XVI, A,1: **Delete**: sentences 1 and 2. **Replace** with: “1. **All Helicopters**. Minimum aircrew will consist of pilot and spotter (spotter will conduct dropping operations). Some missions may require additional personnel with designated droppers, etc.”

## **Chapter 12**

Section VII, B, 4, d: **Replace**: the first two bulleted items *with* one bulleted item: “Contact the local Coroner to make the legal determination of fatality.”

## **Chapter 13**

Section VI, 4<sup>th</sup> bulleted item: **Change** the last sentence (underlined) to: “Do not allow helicopter fueling until the sample is free of contamination.”

Section VIII, C: **Delete** entire part C. Replace with:

**C. Rapid Refueling.** There are two approved methods (Closed Circuit Refueling and Open Port) for fueling helicopters with engine(s) running.

**Closed Circuit Refueling (CCR).** This method of refueling uses a CCR system designed to prevent spills, minimized fuel contamination, and prevent escape of flammable fuel vapors.

**Open Port.** This method of refueling allows flammable fuel vapors to escape.

Rapid refueling of helicopters is permitted if requested by the Government, and the Contractor meets the following requirements:

Rapid refueling procedures in accordance with NFPA 407 3-21 are contained in the Contractor's FAA approved Operations Specifications and "rapid refueling" is authorized on the aircraft approval card.

Notwithstanding NFPA 407 3-21.2(b), a pilot is seated at the controls of the aircraft during refueling operations.

The aircraft is shut down every 2 ½ hours of continuous operation.

Personnel providing onsite fire protection are briefed on the Contractor's rapid refueling procedures.

Government personnel shall not refuel Contract aircraft unless the pilot requests Government assistance due to an emergency situation; or when the Government provides the fuel servicing system and dispensing personnel.

Section IX, D, seventeenth bullet: **Remove** sentence, chart and footnote. **Replace** with: " Fire extinguishers should be provided as specified in the procurement document and in accordance with NFPA 10, Standards for Portable Fire Extinguishers."

## **Chapter 14**

Section I: **Replace:** "Basic Ordering Agreement" *with* "Aircraft Rental Agreement"  
(*Note: this replacement is also necessary throughout the document in many places*)

Section II, first paragraph: **Replace:** "Helicopter Manager" *with* "Helicopter Manager/Helicopter Flight Manager"

Section VI, first paragraph, second sentence: **Replace:** "...will be exceeded.." *with* "...have been (or will be) exceeded..."

## **Chapter 15**

Section XV, C, 2<sup>nd</sup> paragraph: **Add** to end of the 2<sup>nd</sup> paragraph the following sentence (in parentheses): “(See IHOG Chapter 11, XVI, Cargo Freefall and the Interagency Helicopter Rappel Guide for cargo let-down operations.)”

Section XV, E, entire section: Link Aviation Safety Assistance Team ASAT *with* Safety and Technical Aviation Team or STAT.

## **Chapter 16**

Section I, 4<sup>th</sup> paragraph: **Replace** the entire paragraph *with*: “The leader of each law enforcement mission shall implement the rapid risk assessment and management techniques discussed in IHOG, Chapter 3, Operational Planning.”

Section III, C: **Replace**: “...may be advisable..” *with* “...is advisable...”

Section III, D: **Replace** the bold heading, “Airspace Coordination” *with* “Aerial Supervision/Airspace Coordination”. **Change** the first sentence to read: “For multiple aircraft operations, it is recommended that an aerial supervisor be assigned (ATGS, HLCO) to perform aerial supervision and airspace coordination duties.”

Section X, B, Transport of Canines. **Change** paragraph to read: “All canines shall be either muzzled and secured to a hard point or contained in a restrained portable carrier. Canines shall be transported in the rear of the helicopter and accompanied by a trained handler.”

## **Chapter 17**

Section I, 3<sup>rd</sup> paragraph: **Replace** the entire paragraph *with*: “The leader of each helicopter search and rescue mission shall implement the rapid risk assessment and management techniques discussed in IHOG, Chapter 3, Operational Planning.”

Section III, C: **Replace**: “...may be advisable..” *with* “...is advisable...”

Section III, D: **Replace** the bold heading, “Airspace Coordination” *with* “Aerial Supervision/Airspace Coordination”. **Change** the first sentence to read: “For multiple aircraft operations, it is recommended that an aerial supervisor be assigned (ATGS, HLCO) to perform aerial supervision and airspace coordination duties.”

Section X, B. Transport of Canines. **Change** paragraph to read: “All canines shall be either muzzled and secured to a hard point or contained in a restrained portable carrier. Canines shall be transported in the rear of the helicopter and accompanied by a trained handler.”

## **Glossary**

Glossary-22: **Limited Use Helicopter:** **Replace** the existing definition *with*: “Limited Use Helicopter is an interagency term used to denote a Restricted category helicopter or a Standard category helicopter that is designated and utilized in a limited role (not for passenger transport). Use would typically be external cargo transport, water bucket or retardant missions. See IHOG Chapter 2, Chart 2-4 for staffing requirements. See the National Type I & II CWN Helicopter Contract, Section C for further information and requirements.”

Glossary-22: **Add: Line Manager (Line Officer, Agency Administrator)** as a Glossary Item with the following definition: “Agency individual with authority and responsibility for an agency unit; has line item signature authority for policy decisions. Examples: District Ranger, Park Superintendent, Refuge Manager, Field Manager, etc.”

Glossary-34, **Torque**, 4<sup>th</sup> sentence: **Replace**: “...main rotor blades,...” *with* “..tail rotor blades,..”

Glossary-36, **Unimproved Landing Site or Area**, 2<sup>nd</sup> sentence: Add after “basis”, “...approval is necessary and improvements should be made.” (**See Chapter 8**) **Remove**: “... ,and it should be referred to thereafter as a helispot.”

## **FORMS**

IHOG Supplement Forms Package:

**Update** HCM Table of Contents to reflect new forms listed below.

Page A-7 and in IHOG Forms Package, **Replace** old HCM-1, Helicopter Contract Daily Diary form with new OAS-137 Form.

Page A-17 and in the IHOG Forms Package, **Replace**: old HCM-5, Turbine Engine Performance Analysis with new one developed by C. Dingman.



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